

REMARKS

This application has been carefully reviewed in light of the Office Action dated February 4, 2003. Independent claims 8 and 42-47 have been amended. A marked-up version of these claims, showing changes made, is attached hereto as Appendix A. Applicants respectfully request reconsideration of the above-referenced application in light of the amendments and following remarks.

In the present Amendment, claims 8 and 42-45 have been amended to recite in pertinent part that “the pressure of said rapid thermal process chamber is less than atmospheric pressure.” Support for this recitation is found in Applicants’ specification at page 9, lines 2-5.

Claim 46 has been amended to recite in pertinent part that the “crystalline dielectric film [is subjected] to a single wet oxidation anneal process . . . at a temperature of at least about 750°C to about 950°C.” Support for this recitation is found in Applicants’ specification at page 8, lines 28-31.

Claim 47 has been amended to recite in pertinent part that the “non-crystalline dielectric film [is subjected] to a single wet oxidation anneal process . . . at a temperature of at least about 450°C to about 750°C.” Support for this recitation is found in Applicants’ specification at page 8, lines 31-33.

Claims 8, 2-5, 10-12 and 45-47 stand rejected under 35 USC § 103(a) as being unpatentable over Patel, in view of either Emesh or Chivukula, and further in view of Van Zant. Reconsideration is respectfully requested.

The Office Action asserts that the cited references render Applicants’ invention obvious. Applicants respectfully disagree. The above rejection relies on the combined teachings of three different references which are not properly combinable.

Patel teaches an anneal process that is “conducted at a temperature in the range

of about 650°C. to about 850°C. for about five to thirty seconds.” (Col. 4, lines 11-15) (emphasis added). In contrast, Emesh teaches that a “method is provided having a reduced thermal budget, i.e., low temperature anneal (450° – 500°C) and relatively short anneal times (e.g., several minutes) compared with known prior art methods.” (Col. 4., lines 5-8). The primary goal in Emesh is to teach a new method with reduced thermal budget. Emesh further teaches that the “[a]ddition of ozone speeded up oxidation and allowed reduced anneal times to achieve low temperature crystallization. The combined effect of oxygen/ozone in the presence of water vapour was found to reduce significantly the temperature and time required for crystallization to occur,” (Col. 5, lines 39-44) (emphasis added). However, Patel teaches a shorter anneal time than Emesh. As a result, there is no motivation to combine Patel and Emesh since Emesh teaches a longer anneal time with the presence of water vapour.

Patel also particularly benefits from using higher temperatures, e.g., above 500°C, since ozone molecules will disassociate quickly decreasing the anneal time to less than 30 seconds; thus, increasing the diffusion of oxygen into the ferroelectric crystal and reducing the number of lead atoms that are lost. (See Col. 4, lines 18-22). This is the primary benefit that Patel teaches. One skilled in the art would not combine Emesh, which teaches an anneal time of 300 seconds with Patel, which teaches an anneal time of less than 30 seconds. Stated in another way, one skilled in the art would not employ water vapour with Patel’s teachings since Emesh teaches that using water vapour in annealing the ferroelectric layer requires 300 seconds.

The Office Action contends that “one of ordinary skill would be motivated to incorporate steam during the Patel annealing to reduce the *necessity* of higher temperatures required to crystallize the PZT (ferroelectric material), as taught in Emesh,” (Office Action, pg. 14) (emphasis in original). However, Patel teaches that the methods disclosed are “important in that the faster [the] oxygen is provided to the ferroelectric crystal, the fewer the number of lead (Pb) atoms that will be lost,” (Col. 2, lines 34-36) (emphasis added). Accordingly, Patel is primarily directed at decreasing the anneal time such that the number

of Pb atoms lost is decreased. Patel teaches that the quicker the ferroelectric layer absorbs oxygen, the less Pb atoms would be lost. There is no teaching or suggestion in Patel that a lower temperature anneal is needed or desired. In fact, Patel teaches that the bottom electrode 12 comprises a noble metal and one skilled in the art would know that noble metals possess high melting points (Col. 3, line 21). Patel does not teach or suggest using materials that would necessitate using temperatures of less than 650°C. Thus, there is no motivation for a lower temperature anneal since all the materials taught in Patel inherently withstand higher temperatures.

The Office Action further contends, “*Emesh supports higher temperature anneals* to gain higher dielectric constants of the ferroelectric materials and accordingly does not teach away from the anneal temperatures in Patel,” (Office Action, pg. 15) (emphasis in original). As support, the Office Action states that “Emesh teaches that higher temperature anneals increase” the dielectric constant of PZT over lower temperature anneals (Office Action, pg. 15). Applicants respectfully disagree.

Emesh teaches in Table 1, that “annealing in wet Oxygen improved the dielectric constant over annealing in dry oxygen. However annealing in wet oxygen with 1% ozone improved the dielectric constant to > 300,” (Col. 8, lines 34-37) (emphasis added). The presence of wet oxygen and 1% ozone is the only reason the dielectric constant was increased, and not because of a higher anneal temperature as the Office Action asserts. The presence of ozone and wet oxygen results in a higher dielectric constant and not as a result of a higher temperature.

The Office Action further contends that Patel and Emesh are properly combinable since Emesh teaches “reducing the stress in the ferroelectric film,” (Office Action, pg. 3). Emesh teaches that “ferroelectric films may be highly stressed. High Stress may cause poor adhesion to the substrate, which results in peeling, and stress is also associated with fatigue.” (Col. 2, lines 39-43) (emphasis added). However, this is not a concern in Patel. Patel teaches that a “preliminary anneal is then performed to anneal bottom electrode 12 . . . [which] improves the adhesion between the bottom electrode and

the subsequently deposited ferroelectric material.” (Col. 3, lines 29-40) (emphasis added). As a result, Patel teaches reducing the stress in the ferroelectric film through a preliminary anneal. In fact, Patel teaches six different anneals to reduce the stress in the ferroelectric film (See Col. 3, line 63 – Col. 6, line 18). Patel teaches that “this second anneal improves the ferroelectric characteristics,” (Col. 4, lines 64-66). Thus, Patel merely teaches that “[g]ases like oxygen, ozone or air can be used in the annealing process.” (Col. 4, lines 10-11). As a result, there is no motivation to incorporate water with Patel’s teaching since Patel’s multiple anneals ensures that the stress in the ferroelectric film is decreased.

Applicants also respectfully submit that the cited references, Patel and Chivukula, are not properly combinable. Chivukula teaches “[t]he combined effect of oxygen/ozone in the presence of water vapour was found to reduce significantly the temperature and time required for crystallization to occur, i.e., from above 650°C. . . . to about 450°C.” (Col. 14, lines 34-38) (emphasis added). Chivukula teaches an anneal time of at least “30 seconds to several minutes,” (Col. 13, lines 39-40). However, Patel already teaches an anneal time of less than 30 seconds. As a result, one skilled in the art would not combine Patel and Chivukula since Chivukula teaches a longer anneal time. Further, since Chivukula teaches a longer anneal time, one skilled in the art would not use Chivukula’s water vapour with Patel since the combination of water vapour, oxygen and ozone results in a longer anneal. As discussed previously, Patel is directed to increasing the diffusion rate of oxygen into the ferroelectric layer thereby decreasing the anneal time.

Van Zant is relied upon for another feature and does not rectify the deficiencies associated with Emesh or Chivukula. Accordingly, even if the references were combinable as the Office Action asserts, the combination would fail to suggest the invention defined by claims 8 and 42-48.

Moreover, the cited references fail to teach or suggest a method of fabricating a semiconductor device in a rapid thermal process chamber “wherein the pressure of said rapid thermal process chamber is less than atmospheric pressure” as recited by claims 8 and 42-45 (emphasis added). This is an additional reason for the allowance of claims 8 and 42-

45. Claim 45 further recites “a wet oxidation process consisting of steam.” The cited references teach an anneal process using water vapour, oxygen and ozone. This is an additional reason for the allowance of claim 45. Further still, the cited references fail to teach or suggest “subjecting the dielectric film to a single wet oxidation process,” as recited by claims 46 and 47 (emphasis added). Patel teaches six different anneals to achieve a ferroelectric layer with good electrical properties.

Claims 2-5 and 10-12 depend from and include all of the limitations of independent claim 8 and are similarly allowable along with claim 8.

Claim 42 stands rejected under 35 USC § 103(a) as being unpatentable over Patel in view of either Emesh or Chivukula, and further in view of Ohmi and considered with the CRC Handbook of Chemistry and Physics 63<sup>rd</sup> Edition. Reconsideration is respectfully requested.

For at least the reasons provided above, the cited references Patel, Emesh, and Chivukula are not properly combinable. Ohmi and the CRC Handbook of Chemistry and Physics 63<sup>rd</sup> Edition add nothing to rectify the deficiencies associated with those cited references. In particular, the cited references do not teach or suggest subjecting the dielectric film to a single wet oxidation process or that the pressure of the rapid thermal process chamber is less than atmospheric pressure. Accordingly, it is respectfully requested that this objection be withdrawn.

Claim 43 stands rejected under 35 USC § 103(a) as being unpatentable over Patel in view of the excerpt from Ghandi, and either of Emesh or Chivukula and considered with the CRC Handbook of Chemistry and Physics 63<sup>rd</sup> Edition. Reconsideration is respectfully requested.

For at least the reasons provided above, the cited references Patel, Emesh, and Chivukula are not properly combinable. Ghandi and the CRC Handbook of Chemistry and Physics 63<sup>rd</sup> Edition add nothing to rectify the deficiencies found in those cited

references. In particular, the cited references do not teach or suggest subjecting the dielectric film to a single wet oxidation process or that the pressure of the rapid thermal process chamber is less than atmospheric pressure. Accordingly, it is respectfully requested that this objection be withdrawn.

Claim 44 stands rejected under 35 USC § 103(a) as being unpatentable over Patel in view of either Emesh or Chivukula and considered with the CRC Handbook of Chemistry and Physics 63<sup>rd</sup> Edition. Reconsideration is respectfully requested.

For at least the reasons provided above, the cited references Patel, Emesh, and Chivukula are not properly combinable. In particular, the cited references do not teach or suggest subjecting the dielectric film to a single wet oxidation process or that the pressure of the rapid thermal process chamber is less than atmospheric pressure. Accordingly, it is respectfully requested that this objection be withdrawn.

In summary, for all of the reasons set forth above, the cited references, whether considered alone or in combination, fail to disclose or suggest the above-mentioned features of the claimed invention. Allowance of the application with claims 2-5, 8, 10-12, and 42-47 is respectfully solicited.

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APPENDIX A

8. (six times amended) A method of fabricating a semiconductor device comprising:

depositing an oxygen-deficient dielectric film having a dielectric constant of at least about 25 over an underlying layer;

subjecting the dielectric film to a wet oxidation with steam process provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal process chamber at a temperature of at least about 450 °C and for a duration which increases the oxygen content of the dielectric film, said steam provided in a ratio of at least 0.005 relative to other gases present in the rapid thermal process chamber, wherein the ratio of hydrogen to oxygen gases in the mixture is in the range of about 0.1 to about 0.8, and wherein the pressure of said rapid thermal process chamber is less than atmospheric pressure; and

subjecting the dielectric film to a heat treatment in an ambient comprising a stabilizing gas selected from the group consisting of N<sub>2</sub>, O<sub>2</sub>, O<sub>3</sub>, NO, and N<sub>2</sub>O.

42. (twice amended) A method of fabricating a semiconductor device comprising:

depositing an oxygen-deficient dielectric film having a dielectric constant of at least about 25 over an underlying layer;

subjecting the dielectric film to a wet oxidation with steam process provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal process chamber at a temperature of at least about 450 °C and for a duration which increases the oxygen content of the dielectric film, said steam provided by a catalytic system in a ratio of at least 0.005 relative to other gases present in the rapid thermal process chamber, and wherein the

pressure of said rapid thermal process chamber is less than atmospheric pressure; and

subjecting the dielectric film to a heat treatment in an ambient comprising a stabilizing gas selected from the group consisting of N<sub>2</sub>, O<sub>2</sub>, O<sub>3</sub>, NO, and N<sub>2</sub>O.

43. (twice amended) A method of fabricating a semiconductor device comprising:

depositing an oxygen-deficient dielectric film having a dielectric constant of at least about 25 over an underlying layer;

subjecting the dielectric film to a wet oxidation with steam process provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal process chamber at a temperature of at least about 450 °C and for a duration which increases the oxygen content of the dielectric film, said steam provided by a pyrogenic system in a ratio of at least 0.005 relative to other gases present in the rapid thermal process chamber, and wherein the pressure of said rapid thermal process chamber is less than atmospheric pressure; and

subjecting the dielectric film to a heat treatment in an ambient comprising a stabilizing gas selected from the group consisting of N<sub>2</sub>, O<sub>2</sub>, O<sub>3</sub>, NO, and N<sub>2</sub>O.

44. (twice amended) A method of fabricating a semiconductor device comprising:

depositing an oxygen-deficient dielectric film having a dielectric constant of at least about 25 over an underlying layer;

subjecting the dielectric film to a wet oxidation with steam process in a rapid thermal process chamber at a temperature of at least about 450 °C and for a duration



which increases the oxygen content of the dielectric film, said steam provided by a bubbled water vapor system in a ratio of at least 0.005 relative to other gases present in the rapid thermal process chamber, and wherein the pressure of said rapid thermal process chamber is less than atmospheric pressure; and

subjecting the dielectric film to a heat treatment in an ambient comprising a stabilizing gas selected from the group consisting of N<sub>2</sub>, O<sub>2</sub>, O<sub>3</sub>, NO, and N<sub>2</sub>O.

45. (amended) A method of fabricating a semiconductor device comprising:

depositing an oxygen-deficient dielectric film having a dielectric constant of at least about 25 over an underlying layer;

subjecting the dielectric film to a wet oxidation anneal process consisting of steam provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal process chamber at a temperature of at least about 450 °C and for a duration which increases the oxygen content of the dielectric film, and wherein the pressure of said rapid thermal process chamber is less than atmospheric pressure; and

subjecting the dielectric film to a heat treatment in an ambient comprising a stabilizing gas selected from the group consisting of N<sub>2</sub>, O<sub>2</sub>, O<sub>3</sub>, NO, and N<sub>2</sub>O.

46. (amended) A method of fabricating a semiconductor device comprising:

depositing an oxygen-deficient crystalline dielectric film having a dielectric constant of at least about 25 over an underlying layer;

subjecting the crystalline dielectric film to a single wet oxidation anneal process with steam provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal

process chamber at a temperature of at least about [450 °C] about 750°C to about 950°C and for a duration which increases the oxygen content of the crystalline dielectric film[, said steam provided in a ratio of about 0.1 to about 0.5 relative to other gases present in the rapid thermal process chamber]; and

subjecting the crystalline dielectric film to a heat treatment in an ambient comprising a stabilizing gas selected from the group consisting of N<sub>2</sub>, O<sub>2</sub>, O<sub>3</sub>, NO, and N<sub>2</sub>O.

47. (amended) A method of fabricating a semiconductor device comprising:

depositing an oxygen-deficient non-crystalline dielectric film having a dielectric constant of at least about 25 over an underlying layer;

subjecting the non-crystalline dielectric film to a single wet oxidation anneal process with steam provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal process chamber at a temperature of at least about 450 °C to about 750°C and for a duration which increases the oxygen content of the non-crystalline dielectric film, said wet oxidation anneal process comprising only of hydrogen and oxygen gases, wherein the ratio of hydrogen to oxygen gases in the mixture is in the range of about 0.1 to about 0.8; and

subjecting the non-crystalline dielectric film to a heat treatment in an ambient comprising a stabilizing gas selected from the group consisting of N<sub>2</sub>, O<sub>2</sub>, O<sub>3</sub>, NO, and N<sub>2</sub>O.